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DEPRECIATION

Address Delivered before the Convention of Central Water
Works Association, Detroit, Mich., Sept. 25, 1912.

BY

HALFORD ERICKSON

Member of the Railroad Commission of Wisconsin

MADISON, WIS.:
DEMOCRAT PRINTING COMPANY, STATE PRINTER
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DEPRECIATION

Depreciation is an old question in which of late a great deal of new interest has been aroused. The reasons which have brought this question to the front at this time may be traced partly to governmental action and partly to certain economic changes in our industrial and commercial life.

Our state and national governments, for instance, are greatly extending their activities. Among other things they are exercising much closer supervision over public utilities than formerly. They are also beginning to levy taxes on incomes and on net earnings. Activities of this kind, in order to be effectively as well as fairly carried out, require that both the earnings and operating expenses should be properly defined, classified and recorded. In the classifications and rules that have been promulgated in this connection depreciation is generally treated as an operating expense. It is taken out of earnings before the profits are stated.

Further interest therein has also been stimulated by the position in this respect of those who depend upon public utilities for the services they render. Such services have now become necessities. Customers for them therefore insist, as they have the right to do, that the plants be kept in good serviceable condition through adequate provisions for depreciation. They further demand that the money so set aside, especially when contributed by them, be honestly used for the purposes for which it was intended.

Investors are also scanning conditions more closely than formerly. When the units of capital employed in production were small and chiefly owned by the operators themselves there were but few reasons why anyone but the owner should care just how depreciation was provided or the capital kept up. These units, however, have increased in size and with this increase have also come radical changes in the ownerships. The bonds and stocks of our public utility and industrial corporations are now held by investors in all parts of the country. These investors, far separated from their property, now want to know how the property behind these securities is kept up. In fact, they constantly demand information as to whether adequate provisions are made for such depreciation as is taking place in the property.

A correct treatment of depreciation in all its phases is also of the greatest importance to the public utilities themselves. It provides the means by which their property may be renewed when it has to be discarded. It enables them to place the burden of such maintenance or renewals where it properly belongs. It materially assists in establishing equitable relations between the utilities and their customers. It places the utilities in a sound position in this respect with reference to both the courts and so-called public utility laws. It is also in line with proper methods and sound practices from a commercial point of view.

There are also other reasons why proper treatment of depreciation is important. Public utilities for adequate service are ordinarily entitled to rates which will yield reasonable returns for operating expenses, including depreciation, and interest and profit on the investment. These items therefore constitute the cost of the service, the cost which becomes the basis for rates. Such amounts for operating expenses and depreciation may also be deducted from the gross earnings in arriving at the profits or net earnings upon which income and corporation taxes are assessed. Now, if depreciation is either omitted from or understated in the operating expenses, the result is that higher than the true net earnings or profit are shown. This, in turn, may easily lead to unjust reductions in rates as well as to unwarranted increases in taxes or other charges.

In fact, the conditions which have thus been outlined are bringing about a better realization of the importance and nature of depreciation. They are also resulting in inquiries into the forces by which it is caused, the methods by which it can be estimated, how it should be provided for, the methods of accounting connected with it, and many other phases of this question. Depreciation is not only an important subject, but it is too comprehensive for adequate treatment in a short paper. All I shall attempt to do, therefore, is to call attention to a few of its leading features and to outline how it is administered under the Public Utilities Law in Wisconsin. In this connection I will first take up the law itself. The leading provisions in relation to depreciation read as follows:

> "1. Every public utility shall carry a proper and adequate depreciation account whenever the commission after investigation shall determine that such depreciation account can be reasonably required. The commission shall ascertain and determine what are the proper and adequate rates of depreciation of the several classes of property of each utility. The rates shall be such as will provide the amounts required over and above the expense of maintenance to keep the property in a state of efficiency corresponding to the progress of the industry. Each public utility shall conform its depreciation accounts to such rates so ascertained and determined by the commission. The commission may make changes in such rates of depreciation from time to time as it may find to be necessary.
>
> "2. The commission shall also prescribe rules, regulations, and forms of accounts regarding such depreciation which the public utility is required to carry into effect.
>
> "3. The commission shall provide for such depreciation in fixing rates, tolls and charges to be paid by the public.
>
> "4. All moneys thus provided for shall be set aside out of the earnings and carried in a depreciation fund. The moneys in this fund may be expended in new constructions, extensions or additions to the property of such public utility, or invested, and if invested the income from the investments shall be carried in the depreciation fund. This fund and the proceeds thereof shall be used for no other purpose than as provided in this section and for depreciation."

This law clearly recognizes the fact that public utility property, the same as practically all other kinds of property, is gradually depreciating both in value and efficiency, and that these losses must be made good by regular renewals of the property if the investment is to be kept intact and the efficiency of the service maintained. It further recognizes the fact that the cost of depreciation is by its nature an operating expense and should be borne by the consumers in the form of rates that are high enough to cover this cost. In addition to this the law also provides that money so collected from the customers shall not be permanently diverted or used for any other purpose than for the renewal of the depreciated property.

This law is sound in theory and in line with public policy. Its provisions are simple and direct and seem to meet the requirements. To begin with it was not satisfactory to all.

Those, for instance, who for one reason or another desired heavy reductions in the rates charged by the utilities for their services found in full depreciation charges many obstacles to their plans. They discovered that what appeared to be high rates when depreciation was not included in the operating expenses, often turned out to be comparatively low rates when depreciation charges were properly treated. Plants which appear to be very prosperous when depreciation is omitted from consideration are often found to be only moderately so, if not actually losing propositions, when from one to more than five per cent on the investment, depending on the conditions, are allowed for depreciation.

Many operators of public utilities also objected to this law. It especially failed to find favor among those who in the past had been able to provide for renewals by new capital issues, and who expected to be able to do so in the future, and who, in this way, could devote the amount earned for depreciation to dividend payments and other purposes of this kind. It was also looked upon as an unjust innovation by those who hold that, for some utilities at least, there is an appreciation in the valuation of their property which tends to more or less fully offset the depreciation therein. As was to be expected, this law has also met with some opposition from those who object to the keeping of such exact records as are necessary in order that provisions for depreciation may be properly handled and cared for.

It is only just to say, however, that many of these objections now seem to be wearing away and that the provisions in the law are now more generally looked upon as just and fair both to the public and the utilities.

NATURE OF DEPRECIATION.

The Century Dictionary defines depreciation as

1. The act of lessening and bringing down value;
2. A fall in value; reduction of worth.

Significant as these definitions are, they hardly convey to one's mind everything that is implied in the term depreciation as understood by those who are in actual charge of the operation of public utilities and other industrial enterprises. To fully comprehend its meaning from this point of view, it would almost seem necessary to come into actual contact with operating plants of this kind. As soon as the equipment has been placed in position and the plant put in operation, it begins to fall off in value. Buildings, machinery, and other equipment are subject to the destructive ravages of time, and sooner or later will become useless from wear and tear and from general decay. Because of new inventions and unexpected developments and growth in the business such equipment may even have to be replaced by better, more efficient, or more powerful units long before it is worn out. While some parts show greater resisting power and will serve their purpose longer than other parts, all are on the way to the scrap heap. Good upkeep and careful usage may prolong the useful life of many of these parts but cannot prevent their ultimate fate.

Depreciation is important for other reasons than those given above. It is one of the important elements that enter into the determination of the present value of the physical property of public utilities when it has to be ascertained for rate making, purchase and sale, capitalization, and other purposes.

Depreciation is generally due to causes which may be classified under ordinary wear and tear, general decay, obsolescence, and inadequacy.

Wear and tear, or minor renewals are ordinarily made up of repairing and replacing minor equipment as well as the smaller parts of the larger units of the equipment as these wear out, break, or in some way are lost. Examples of such repairs and renewals may be found in the wearing out of the bearings on machines, wheels on cars, tires on wagons, shoes on horses, commutators on dynamces. Such repairs in an operating plant are almost constantly going on and the expenses involved are therefore fairly regular. As these expenses are about the same from year to year, they can be charged directly into the operating expenses without causing serious fluctuations in the net earnings. While expenses of this kind are in the nature of depreciation, they are, as a rule, not included in depreciation allowances but charged separately into the operating expenses.

General decay is that part of wear and tear which is due to age and which cannot be made good through such ordinary repairs as those just described. This deterioration also begins as soon as the equipment is placed in operation and goes on until it becomes unsafe or useless. Wooden parts are certain to rot and decay; iron rusts, wears, and wastes away. Thus, car and wagon bodies and other equipment become so weakened by decay that screws, nails and bolts will no longer hold the different parts together. Engines, boilers, and other machinery wear out and become useless; so do buildings and practically all other equipment. There is little or nothing about a plant, except perhaps land, that does not sooner or later reach such state of decreptitude that it no longer pays to repair and keep it in use.

Obsolescence here means such lowerings of the value of property as are due to progress in the art, or to the development of something newer, more economical and more effective generally. It often happens, especially in the electrical field, that new types of apparatus are brought into use which are so much more efficient than existing apparatus that it becomes necessary to discard the latter, often long before it is worn out. Examples of this are found in the displacement of steam reciprocating engines by steam turbines, which, in turn, may also necessitate changes in boilers, generators and other equipment. Such changes, even when the greater efficiency of the new equipment and when the value of the displaced property, either for use or sale, is taken into consideration, may result in net losses to the utilities. Another example in point is where steam plants are discarded because of the development of water power. Owing to municipal requirements public utilities may also have to replace and change much equipment while it still is in good serviceable condition. Thus overhead wires or transmission systems may have to be changed or removed. Losses incurred for these and other similar reasons, especially when they could not have been avoided by the exercise of ordinary judgment and foresight in connection with the original design and construction, should undoubtedly receive consideration in depreciation allowances.

Inadequacy is that reduction in value which results when, because of unexpected developments and growth in business, existing equipment has to be replaced by equipment of greater capacity and size. In water works, for instance, it often happens that larger engines, boilers, pumps have to be put in long before those in use are worn out. This is also often true of buildings, mains, and other equipment. There are also instances when similar changes are brought about through city ordinances and other similar requirements. Such changes occur even where the original design and installation was of the best. That losses arising from such causes and under such circumstances should not be disregarded in dealing with depreciation, would seem rather obvious.

There are losses in value because of certain non-insurable accidents arising from explosions, floods, wind, electrolysis, and other forces. Such losses, however, can seldom be determined in advance. They are also, as a rule, of rather infrequent occurrence as well as extremely uncertain as to the extent of the damages inflicted. They are, in fact, of a different class of losses from those which are ordinarily included in depreciation. The best practices in connection with providing for such losses would therefore seem to be to charge them directly to the operating expenses for the year in which they happen, when small, and to distribute them over longer periods when they are too large to be conveniently met in any one year.

Depreciation is an Operating Expense.

That losses in value, such as come under wear and tear on the one hand and under general decay, obsolescence, and inadequacy on the other, are a part of the cost of production or of the services rendered by public utilities would seem to be clear. It is obvious from the nature of these expenses as well as on the ground of public policy. Owing to their regularity and character it would also seem that the former can best be met by being charged directly to operating expenses as they occur; and that the cost of general decay, obsolescence, and inadequacy, being more irregular and also, as a rule, greater in amount, should be provided for in advance by charging each year's expenses through depreciation accounts with its prorata proportion thereof.

Investors in public utilities, at least under normal conditions, are entitled to have their investment kept intact. If they are not within reasonable limits assured of this, the necessary capital will not be forthcoming. These conditions prevail regardless of whether the plants are privately or publicly owned. In both cases the rates charged for the services should be high enough to cover all reasonable expenses, including depreciation and interest charges.

The cost of the services rendered by public utilities includes not only such current expenses as labor, material and supplies of all kinds, but such deferred charges as insurance, taxes, depreciation, interest on the investment, etc. About the only difference in effect as between such current and deferred costs is that the former are met currently, perhaps monthly, while the latter are met at longer and more or less regular intervals. Current expenses are met as they occur by direct charges to some account under operating expenses. Deferred costs are met, say, once a year or once in several years, but they should be estimated or ascertained in advance and distributed in equal monthly and yearly parts over the period they cover. Taxes, for instance, being met yearly, should be borne by the products for the year and shared in equally by each of the twelve months. Depreciation, on the same principles, should be borne by the entire output during the life of the property it covers and distributed in monthly and yearly proportions in the operating expenses for this period. Such distribution is necessary in order to determine the true net earnings per month or year, and also in order to show at frequent intervals the total cost as well as the costs per unit of the products or services rendered. The importance of such costs, not only for operating but for other purposes, is well understood. It is also readily seen that reliable figures upon these points cannot be had unless both current and deferred costs are included in the expenses.

The nature of such costs may be further illustrated. If a public utility corporation rented or leased its plant, the amount paid on such rental would be likely to just about cover depreciation and interest on the investment therein. This rental would also be regarded as a part of the expenses of the corporation and as a part of the cost of the services it furnished. The situation in this respect is in no important particular different from the one which is presented when the company owns its own plant. In this case the cost of this plant appears in the form of depreciation and interest charges, and these charges, divided up into monthly or yearly installments, are as much a part of the cost of the services rendered as was the rental paid for the leased plant. The cost in both cases is made up of depreciation and interest, and these are in either case necessary charges against the products turned out during the period covered.

To charge depreciation to the construction account and to meet its costs by the issuance of new securities, as is so often done, is highly objectionable from almost every point of view. It soon results in excessive capital issues and capital charges. It may shift the cost of depreciation from those who should bear it and it often enables those in charge to directly or indirectly declare dividends to which stockholders are not entitled. Such practices are certain to result in unfair profits to some and serious losses to others. They also tend to retard the proper development of the business and services of the utilities. They have this effect because under them the capitalization soon becomes so high that required additional capital cannot be obtained for new and much needed extensions of the plant and for improvements in the service. Such practices are also bad from an ethical point of view. Improper treatment of depreciation and the amounts set aside to cover it is, therefore, in the long run likely to prove injurious to either the customers or the investor, or the public as a whole. In fact, it may even happen that all three classes will be detrimentally affected thereby. It is clearly contrary to public policy.

METHODS OF ESTIMATING LIFE OF PROPERTY.

The real work in connection with depreciation consists of estimating the probable life of the property involved; of determining the amount that should be set aside annually to cover such depreciation; and of deciding upon proper methods of recording the same upon the books of the company.

The most complicated and difficult part of this work is, perhaps, that of estimating the probable life of the different classes of property which make up a utility plant. There are many reasons for this. This life varies with the kind or class of property or equipment and with many other conditions. In the case of water works some parts of a plant have a life of only five years or less, while other parts again have lives of ten, fifteen, twenty-five, fifty, and even a hundred years. These parts must be classified on the basis of age and dealt with in such age groups.

The life of the property in each of these classes as well as of the plant as a whole is greatly affected by many local conditions. A plant, for instance, that is well constructed of the best material will last longer than one that is poorly constructed of poor material. This is in line with the laws of nature. High grade construction and material count for as much in property used by public utilities as it does in property used in other fields. Plants that are properly designed in the light of both present and future needs will have more years of useful life than those of which the contrary can be said. The former are fitted with the latest type of the most approved equipment, so adjusted as to operate with the least possible friction, not only when meeting the smaller present demand but when it takes care of a growing future demand as well. That plants of this type will not only better resist the ravages of time and longer escape the renewals that follow progress in the art and growth of the business than is the case with a plant of an inferior type, is too plain for argument. By this is not meant that provisions for future growth is a matter that may not be easily overdone. Owing to depreciation and other factors it is generally not economical to attempt to provide for conditions that are not likely to materialize within a reasonable time.

The way in which plants are operated is also an important element. Overworked plants are quickly injured. Certain parts therein are likely to have to be renewed, often long before the end of their ordinary life. This is also the case of plants that are not properly kept up by ordinary repairs, etc. In fact, plants that are carefully watched in this respect and on which minor renewals and repairs are promptly made as soon as needed, will last much longer than plants which are neglected in this respect. This, as in many other instances, is a situation where a stitch in time is apt to save nine. Excessive heat and humidity as well as extremely cold weather are also apt to seriously affect the life of at least certain classes of property.

Engines that are properly selected, placed, and operated and that in all respects are well adapted to their work, will last much longer than engines selected without much of any reference to these matters, and which may be uneconomical and badly used. This is true not only from the point of view of general decay, but from that of obsolescence and inadequacy. What applies to engines in this respect is equally applicable to boilers, standpipes, buildings, and other equipment.

Even cast iron and other pipes are more or less affected by character and quality; by the kind of soil in which they are laid; by proper laying and by whether they are disturbed by other trenches; by the kind of water that passes through them;

as well as by electrolysis and other forces. Their life may also be shortened by a rapidly growing demand for fire and other service.

Practically all kinds of equipment appear to last longer when used throughout their lives for the purposes for which they were intended than when shifted about from one use to another and from place to place. Some parts depreciate very rapidly at first and then more slowly later on. This is especially true when sales value is considered. Equipment becomes secondhand almost as soon as placed in operation. If it has to be sold, then it will have to go at secondhand prices. Other parts, again, depreciate more slowly at first, even up to shortly before the end of their life. This applies with especial force when service value rather than sales value is considered.

It is also necessary to know how long the different parts have been in use as well as the expenditures made thereon for repairs and renewals. These facts can usually be obtained from the books and records of the company. Such data as the original cost, or cost of reproduction new, of the property, its present value, its scrap and minimum service value, are also important.

In this connection it is also of importance to know the so-called scrap value, or minimum service value, of the various parts when discarded or replaced. This value depends very largely upon whether the parts or units can be fixed up and used again, or whether they must be treated as junk. In the former case they may have considerable value. In the latter case the value is naturally less, though even in this case it often amounts to considerable sums. In both instances the values assigned the parts are those which are obtained from the fullest possible inquiries into all the facts which affect such values. These values, when thus found, are deducted from the cost new in assigning the life of the parts for depreciation purposes.

In making proper allowances for those elements of depreciation which are represented by the terms obsolescence and inadequacy, it is of special importance to know whether the equipment used was up to date at the time it was put in and whether the plant was properly designed from an engineering point of view. If poor judgment was used in either case, it is by no means clear that the losses which result therefrom should be shifted to the consumers.

In view of these and other facts, it is apparent that it cannot often be safe to estimate the life of property of this kind without detailed and accurate information as to its condition and the way it has been used. In estimating their life, therefore, each part of the plant should be carefully examined and even tested by someone who by training and judgment is qualified to pass upon such matters. In addition to this it is also necessary to consult facts and life tables covering like property under various conditions, as well as to avail oneself of all other information in point. In the actual work of determining the life some appear to depend upon inspection and judgment alone, while others seem content to rest their case on existing life tables of other similar property. Neither method, when depended on alone, seems to be entirely safe. Judgment is often affected by personal interests, natural bias, and other factors. Likewise, the conditions found for any given property at one time are not always likely to correspond to the conditions found for like property of the same age at another time and place. Nor can general rules always be depended on to fit special conditions. It therefore seems to me that the safest way is to combine both methods.

A careful examination of the property and the conditions by which its life is affected, supplemented by a close study of the facts for other like property as presented in life tables and in other ways, would certainly seem to lead to the best and safest results in such work. This method would offer opportunities for such comparisons of facts and tests of judgment as can be had in no other way. On the whole it seems much superior to any other method. I have reached this conclusion after listening to volumes of testimony and after having examined hundreds of reports upon the subject, as well as from such studies as I have been able to make of the properties themselves and of the methods under which their lives were estimated.

To say that the experience of others as expressed in life tables, especially when these tables are accompanied by the facts upon which they are based, is of no value if not actually misleading in estimating the life of property, would almost seem like saying that history is of no value in judging present and future conditions. It should not be forgotten in this connection that it is the present condition only of the property that can actually be seen. The past of this property is largely hidden, except for such light as may be thrown thereon by its present condition and by the records of the company. The future of the property is even more problematical. Such opinions as are formed on this point must, in the very nature of things, be based on the probable past and future conditions. As such conditions are largely represented in the kind of life tables and facts I have in mind, it would hardly seem that they can be entirely without value.

The engineering staff of the Wisconsin commission, in determining the life of the various classes of property and the amount of the depreciation that has taken place therein, not only carefully examine the property and make full notes on all the facts by which its condition appears to be affected, but they also make use of life tables of various kinds, as well as of other facts and information that have any bearing upon the matter. Among other things they have prepared tables which show the per cent conditions on the sinking fund basis for various lengths of life as high as one hundred years. This per cent condition, when used, is still further controlled by the condition of the property as ascertained by actual inspection. When this condition is good the property is rated at about 100 per cent of its unexpired life. When it is fair, the property is rated at about 90 per cent of its unexpired life. When it is poor, it is rated at about 80 per cent of this life, and so on.

These tables are rather complicated. This is also more or less true of the methods by which they are applied. For these reasons I shall not attempt to describe them in detail. They are frequently used, however. The results obtained in this way have often been tested by other methods. In fact, it has been determined again and again that such tables, supplemented by close personal inspection of the property, almost invariably lead to more reliable results than would be obtained from inspection alone.

Composite Life of Plants.

The conditions of the various parts of the plant as thus determined, together with facts showing the cost new and the scrap value of these parts, are then used as the basis for computing the life of each one of these parts, as well as of the plant as a whole.

One method that is sometimes used in computing the composite life of plants from such estimates is the so-called "dollar-years" method. Under this method the property is first classified as to the cost-value less scrap and as to age. Then it is determined how many times the property in each of these classes will have to be renewed up to the end of the life of that class whose life is the longest. The next step is to compute the total cost of all the renewals that are required of all the property in each of these classes during this period. These costs times their lives in years will give the total dollar-years. When the total dollar-years for all classes is divided by the total cost of all renewals during the period, then the quotient obtained represents the composite life of the plant. During a hundred year period property having a life of five years will have to be renewed twenty times. The number of renewals that are needed during any given period thus depend on the length of this period and the life of the property.

Another method that is frequently used by us for obtaining the probable life of the plant as a whole consists in determining the amount that is annually required for renewing the property in each class at the end of its life, and of dividing this sum for all the classes into the total cost new of all the property less its scrap value.

If we admit the existence of such losses in property as those included in depreciation, as well as the economic necessity for including these losses in the cost of the service; if we concede further that it is possible to estimate the extent of such losses, that is the life of the property, with a fair degree of accuracy, then the next question to be considered is, how should these anticipated losses be financed or provided for.

Methods of Providing for Depreciation.

In discussing the methods of providing for depreciation or of financing the same it is important to obtain as clear an idea as possible of the relations that obtain between repairs and minor renewals on the one hand and depreciation, or other renewals, on the other. To point out clearly just where the line should be drawn between renewals which are usually classed as repairs and renewals which are ordinarily classed as depreciation, is an exceedingly difficult task.

In actual practice this line also appears to be very loosely drawn. Larger corporations, such as railways with thousands of miles of lines, and such as industrial enterprises with many plants, often appear to get along very well with repair or maintenance accounts alone. Their business is so extensive that renewals as they occur can be charged to repairs without seriously disturbing their net earnings. Owing to the very extent of their property, their renewal requirements are likely to be fairly regular from year to year. Such methods, however, while they may be adequate for operating purposes, fall short of keeping the investment intact. Under it no provisions are made for depreciation before the units are renewed.

Other companies, again, while they have charged all renewals, so far made, direct to the repair and maintenance accounts in the operating expenses, have also besides this set aside something for other losses, probably of a contingent nature. There are also some who restrict repair charges to the regular outlays for minor renewals and upkeep, and who charge the more important renewals to the depreciation account. Many limit repairs to the renewal of parts which last only about one year and charge depreciation with all other renewals. Others, again, charge all renewals to depreciation and at the end of the year, for the purposes of their reports, separate out such items as in their judgment constitute repairs and transfer the same to the repair accounts through the required entries. Companies are also encountered who charge the depreciation accounts with the renewal of entire units only, while the renewals of parts of such units go into the repair accounts. In water works, under this method, the replacement of boiler tubes would be classed as repairs, while the replacement of the entire boiler would be classed as depreciation. Similarly, the renewals of valves, pistons, etc., on engines would be designated as repairs, and the replacement of the engine itself would be classed as a depreciation charge.

In actual practice, the determination as to how these charges should be divided as between repairs and depreciation is usually left to the judgment of some one in either the accounting or in the operating department. This may be illustrated by the practice of one company which on the whole appears to make ample allowance for both the minor and the more important renewals. In this case the distinction between repair and depreciation charges is largely determined by office routine or by the size of the job. Renewals which are comparatively small are charged directly to repairs or maintenance. Renewals which assume substantial proportions are, upon approval of someone in authority, charged to depreciation.

In the classification of accounts promulgated for public utilities by the Wisconsin commission, it is in a general way provided that the losses in value of all tangible property which lasts one or more years shall, in equal monthly payments, be charged to the depreciation account. This leaves renewals of property lasting less than one year, and all hand and portable tools without regard to their life, to be covered by the repair or maintenance accounts. This classification also provides that, when the cost of the units renewed is greater than its original cost, this excess shall be charged to the construction accounts.

These provisions in the Wisconsin classification of accounts are substantially adhered to by many of the plants in the state, but there are some among them who, for one reason or another, prefer some other division between repairs and depreciation than that given in the classification. Others, again, dislike changes and are not as ready as they might be to readjust themselves to more modern methods. Smaller plants are not always in position where they feel it is convenient for them to keep their records in the manner they should be kept. There are also some whose earnings are not large enough to cover operating expenses, interest on the bonds, and leave a surplus for depreciation, and which are so situated that under existing conditions they cannot be made to earn enough for this purpose. Conditions of this nature cannot be entirely disregarded. While the commission is doing its best to bring about the adoption of records that are simple and easily kept, as simple, in fact, as they can be made without eliminating the essential features which make records necessary, it has endeavored to do so in such a way as not to unduly embarrass anyone. Even public utilities are sometimes a little slow in realizing that proper systems are, in the long run, the most economical.

But no matter just how depreciation is provided for, the renewals themselves, outside of repairs, occur, as stated, at such irregular intervals that it is necessary, in order to avoid serious fluctuations in the net earnings, to make regular monthly or yearly charges for the same to operating expenses. During some months or years, for instance, extensive replacements may be required. During other months and years, again, and even for several years, none at all may be needed. All months and all years, however, have, in a sense, contributed towards the depreciation that has taken place in the property. Under such circumstances it is undoubtedly more equitable to distribute depreciation in more equal annual charges during the life of the property than to charge the cost of the renewals to the expenses for the month or year in which they were made.

Four methods of providing for depreciation and of equalizing it as between the various years in the period covered are often suggested. These methods are: the "straight line," the "sinking fund," the "diminishing value," and the "annuity methods." The first two in order of these methods seem to be the ones that are most generally employed in this country. The last two, or the diminishing value and the annuity methods, are mostly suggested by English writers upon this subject. They have also been quite fully explained by Professor H. R. HATFIELD in his book on accounting.

These methods are of the greatest importance in this connection and will therefore be more fully explained. In order to illustrate the results obtained in actual practice under each one of these methods, they have been applied to the depreciable property of the electric lighting and power plant, the composite life of which is shown in tables 3 and 4. The electric plant was selected for this purpose because its life is short and the calculations therefore comparatively few. The results are given later in tables 4 to 9, inclusive. They show, among other things, the amounts that must be set aside annually from earnings under each of these methods to cover the depreciation charges. They show this for the property in each life group as well as for all the groups or the plant as a whole. It will be noticed that the so-called overhead charges in construction were excluded from the costs upon which the depreciation charges were figured. This was done more as a matter of convenience in the calculations than because some at least of these overhead costs are not proper items to be covered by depreciation allowances. The formula used in the calculations in each case is also given in the respective tables.

In order to shed further light on these methods and enable some conclusion to be drawn as to their respective advantages or disadvantages, tables have also been worked out and included herein which show for each method, for the period given, the respective amounts placed in the depreciation reserve to cover depreciation, and withdrawn therefrom to cover the cost of renewing discarded property, together with the cumulative balances on hand in the reserve. In these calculations it has been assumed that each part of the plant is to be renewed at the end of its estimated life, and that the life of the plant is therefore perpetual. It has further been assumed that the amount set aside from year to year remains the same, and that there are no changes in the cost of the property during the period. The computations in the tables cover a period of 75 years, which period corresponds to the life of that group of the property which has the longest life. This period was chosen in order to show the condition of the reserve account up to the time when all the property had been renewed at least once. These facts are given in tables 10 to 15, inclusive.

Before these methods are further explained and illustrated it should be pointed out that the cost new of the depreciable property of the electric plant in question amounts to $454,574; that the scrap value of the same foots up to $62,331; and that the balance between this cost new and scrap value is $392,243. This balance represents the total depreciation, or the cost of the renewals that must be provided for during the composite life of the plant in order to keep the investment intact. As this composite life of the plant as a whole is about 17.15 years, the average amount per year is about $22,878.

It should also be explained that with an annual requirement for depreciation of $22,878, the total requirements for 75 years would amount to $1,715,850. The cost of the renewals actually made during this period amount to $1,580,071, or to $135,779 less than the amount thus set aside for this purpose. This difference represents such depreciation as has taken place in the property in use, the life of which has not as yet expired. In other words, this balance of $135,779 is for depreciation that has accrued but which will not have to be met until the property involved has to be replaced. The sum of $1,580,071, which was thus given as the cost of the renewals actually made during the period, remains the same regardless of the methods under which depreciation is provided for or financed. The credits to the depreciation reserve, however, or the total amounts that have thus been set aside for depreciation, vary with the methods thus employed. This is therefore also true of the balance for accrued depreciation. Thus, under a two per cent sinking fund basis the credits to this reserve would amount to $1,701,891, or to $121,820 in excess of the actual renewals; while under a four per cent sinking fund basis the credits would foot up to $1,698,760, and the balance to $118,689. For the diminishing value method the credits would be $1,815,897, and the balance $235,826. For the annuity method the credits would be $1,664,777, and the balance for accrued depreciation $84,706. While the total allowances for depreciation thus exceed the total cost of the actual renewals during the period, there are many individual years therein when the former are the greatest.

Under the straight line method, the amount that should be set aside annually to cover depreciation is obtained by dividing the balance between the cost new of the property and its scrap value by its estimated life. As in this case this balance, as stated, was $392,243, and the composite life of the plant 17.15 years, the annual amount to be set aside for depreciation is $22,878. These facts are illustrated in table 4. This table also shows that the annual rate of depreciation varies from 20 per cent for the property in the five year group to 1.33 per cent for the property in the seventy-five year group. The average rate for all of these groups is 5.83 per cent on the depreciable amount.

The straight line method is much more simple and direct than any of the other methods. It is advocated by the interstate commerce commission, and for certain purposes also by the Wisconsin and other state commissions.

Under the sinking fund method it is assumed that the amounts set aside for depreciation are invested or used at compound interest, and that the interest so obtained also goes into the depreciation reserve. Since in this case the interest on the sum thus set aside, as well as these sums themselves, becomes a part of the fund, it necessarily follows that the latter need not be as large as would be the case if no interest was allowed thereon. On a 2 per cent sinking fund basis the amount that must be annually charged to operating expenses for depreciation is $19,454, or about 4.96 per cent on the property. On a 4 per cent sinking fund basis, the amount so set aside and charged to expenses is $16,543, or about 4.20 per cent on the property. When the interest on balances from this time on also is included, it is found that the amounts placed in the fund gradually increase. With compound interest at 2 per cent, the annual allowance increases from $19,454 for the first year, to $23,249 for the tenth year, and $26,707 for the seventeenth year, and that at 4 per cent compound interest, the annual allowances increases from $16,543 for the first year, to $23,545 for the tenth and $30,985 for the seventeenth year. When both the principal and the interest allowances are thus considered, the total amounts thus set aside for depreciation will be found to be considerably higher than when the former alone is considered.

It is seen from these figures that under this method the estimated depreciation, cr the provisions therefor, are lowest at first and are then gradually increasing from year to year. This is also, as a rule, the course that is followed by the earnings of public utilities. It is further held that it is in accord with the course of actual depreciaticn from the point of view of the service value of the property. As a part of the provisions for depreciation is made up of interest allowances on the balances in the depreciation fund, it also follows that, under this method, the direct charges to operating expenses for this purpose are correspondingly lower. These facts tend to place this method in rather favorable light. It is also used by the Wisconsin commission, when it seems to be the method that is best suited to the conditions.

Under the diminishing value method, a certain percentage is determined which is first applied to the total cost-value for the first year. The depreciation allowance thus obtained is then deducted from the original cost-value of the property. The same percentage is then applied to this reduced value the second year, and to the diminishing values for each year thereafter until the end of the estimated life of the plant, when the balance remaining should agree with the scrap value of the property. In this way the base to which depreciation is applied during this period is continually diminishing and the annual depreciation allowance is constantly decreasing.

Under this method the rate for depreciation is high, amounting. for the plant in question here, to 10.92 per cent. This high rate, which helps to make the charges high at first, is later on offset by decreases in the amounts to which it is applied. Thus it is found that, while the depreciation charge is

$49,639 the first year, it has decreased to $44,219 the second year, to $17,533 the tenth year, to $9,834 the fifteenth year, while at the end of the period it is wiped out entirely, when the scrap value only remains.

In favor of the diminishing value method it may be said that under it the charges are highest during the earlier years, when the cost of repairs are the lowest, and that these charges decrease as the cost of repairs increases. Another argument frequently offered in support of this method is, that during the earlier years the new equipment is competing with old equipment, while in the latter years it is competing with more efficient machines of a better type; for these and other reasons the plant is better able to bear a heavy depreciation charge in the earlier years than later on. The obvious objections to the method are that it involves a somewhat complicated mathematical calculation, that the charges are heaviest in the earliest years of the life of a plant, when the earnings may not be sufficient to care for the entire cost of production. It would hardly seem to be a suitable method for public utilities with a continuous existence.

The annuity method is based on the assumption that the depreciation charges should be high enough to write off the value of the property during its life, as well as to cover the interest charges from year to year on the gradually diminishing value of this property. It is also based on the further assumption that interest is allowed on the balances in the depreciation reserve in much the same way as under the sinking fund method. As the annual charge to operating expenses is constant or remains the same throughout the period, and as the proportion of this charge that is required to cover the interest is gradually decreasing, it necessarily follows that the depreciation charges are increasing. These increases in the depreciation charges represent the interest that is allowed on the balances in the depreciation reserve. That part of the annual charges to operating expenses which is represented by interest on the value of the property, is also credited to the interest accounts.

When, under this method, six per cent is allowed for interest on the diminishing value of the property on the one hand, and on the balances in the depreciation reserve on the other, it is found that the annual gross charge to expenses is $41,005, of which, for the first year, $27,274 represents interest, and $13,731 depreciation. These charges, however, are gradually changing.

For the tenth year, for instance, the proportion for interest has decreased to $23,108. For the seventeenth year, again, the former has been reduced to $6,124, while the depreciation has been increased to $34,881. This method does not seem to be used by public utilities, nor is it adapted for such use.

As to which of these methods of providing for depreciation is the most economical, is a matter that may be dependent on conditions. As depreciation is an operating expense and enters into the cost of the services, it would seem that for the consumers at least, that method is the most advantageous under which the annual charge to operating expenses is the lowest, for the lower the cost of the services, the lower the rates are also apt to be. The method that would seem to best meet this condition is the sinking fund method or some method that is based on similar principles. For about the only way in which these charges to operating expenses can be reduced is through such use of the balances in the fund or reserve account that interest may be obtained thereon.

Whether this in the same sense also applies to the management or owners of public utilities, is doubtful. It is quite likely that, in most cases at least, the management would prefer to charge expenses with the full cost of depreciation on the straight line basis and to be allowed to use the money in the reserve as they see fit, without much of any restrictions as to how the income from this use should be applied. At any rate, they probably feel that they should not be required to pay a higher rate of interest for such use of the balances on the reserve account, than the rate they would bring as savings deposits. That the use of these balances should not be unduly restricted is quite obvious. On the other hand, fairness also demands that the customers should, to some extent at least, share the benefits from such use.

The facts given in the accompanying tables indicate that the amount set aside for depreciation, even when interest allowances are included therein, are somewhat lower under the sinking fund than under the straight line method. This also applies to cumulative balances in the reserves. While much depends upon how these reserves are used and how the returns from such use are treated in the records, it is likely that those methods are the most economical as well as the most equitable, all around, under which depreciation reserves are credited with at least something for the use of its balances.

In a growing utility or plant the offsetting assets to the depreciation reserve are quite likely to consist of additions to the plant. That is, the amounts set aside for depreciation are more likely to have been used for such extensions than to have been kept on hand or to have been invested in outside interest bearing securities or properties. The use of depreciation reserves for new extensions to the plants is also specifically sanctioned by the Wisconsin Public Utilities Law, because it provides "that moneys in the fund may be expended in new construction, extensions or additions to the property of such public utility, or invested; and if invested the income from the investment shall also be carried in the depreciation fund".

These provisions were included in the law to meet the demands of actual conditions. For it frequently happens in practice that depreciation reserves can be much more advantageously used in connection with new extensions than in almost any other way. If such funds are placed on deposit or invested in quick assets, they are not likely to bring a much higher return than four per cent. This is a much lower rate than that which the company is likely to have to pay for additional capital. By borrowing, so to say, from the depreciation fund until these funds are needed for renewals, the company may secure the use of considerable money for capital purposes, on a basis that is advantageous to itself as well as to its consumers.

It should be clearly understood, however, that by using the depreciation fund for extensions, the owners are only temporarily relieved from furnishing the necessary capital therefor; for in effect the money thus obtained from the depreciation fund has merely been borrowed, and, like other loans, should be repaid. It must be restored to the fund when needed therein for renewals. The money by which it is thus repaid may have to be obtained in a manner similar to that by which the capital for the extensions would have had to be raised at the time they were made, had the balance in the depreciation reserve not been available for temporary use.

In order to further illustrate the results obtained under the methods employed in this work by the Wisconsin commission, two tables are included which show for 23 water works and 23 electric plants the population served, the cost of reproduction new of the plants, the per cent condition at the time of appraisal, the present value (that is, the cost new less depreciation), the composite life of the depreciable property of the

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plants, and the annual rate of depreciation on a straight line basis. The table covering the water works shows, among other things, that their composite life ranged from 37 to 62 years and that their rate of depreciation ranged from 1.24 to 2.44 per cent. The table for the electric plants shows, in a similar way, that the composite life of these plants varied from 14.69 to 20.80 years, and that the rate of depreciation ranged from 2.35 to 6.20 per cent, depending on conditions. These tables are numbers 16 and 17.

How Depreciation May be Recorded.

This leads to the question of how depreciation is booked or treated from an accounting point of view. Depreciation may, of course, be recorded in more than one way. English and German accountants favor the writing down of the book value of the property. Under this method anticipated losses are charged to the depreciation account in the operating expenses, or to the loss and gain account, and credited to the property accounts. In this way the balances in these property accounts, from time to time, represent the value of such property which has not been covered by allowances for depreciation.

Another way is to create a depreciation reserve or liability account and place to its credit all allowances that are made for the purpose of offsetting losses in plant or property value due to depreciation. The corresponding debits are then made to the depreciation account in the operating expenses, or to the loss and gain account. When property has to be renewed the cost new of the same, less scrap value, is charged to the depreciation reserve and credited to the cash account. The detailed transactions, as thus recorded, will disclose what provisions have in this way been made for depreciation, as well as just how these provisions have been applied for renewals.

The latter method is that provided in the uniform classification of accounts prescribed by the railroad commission of Wisconsin, it being therein provided that as a part of operating expenses ''There shall be opened a 'Depreciation account' to which shall be charged monthly, crediting the depreciation reserve, an amount equal to one-twelfth of the estimated annual depreciation of the tangible capital in the service of the utility''. Similar provisions are made in the standard classification of accounts of the interstate commerce commission and other commissions.

This method is usually considered preferable since it allows the book value to remain intact, which may be desirable for historical reasons and since it discloses a record of what provisions and what uses have been made of the reserve for depreciation. In order to clearly set forth the purpose of the reserve, the depreciation liability item may be shown in the balance sheet as a deduction from property, thus intimately associating the reserve with the asset it is designed to offset and removing it from any connection with surplus with which it has no relation.

The depreciation reserve thus created is a recognition of the liability of the undertaking to meet the loss due to depreciation when such a loss occurs. If such depreciation reserve has been set aside out of net earnings actually earned during the year, certain asset accounts necessarily exist to offset or care for the depreciation requirements when they fall due. A portion of these assets may consist in plant, a portion in current assets, and a portion in special funds or cash on hand. In any investigation of depreciation charges it is always pertinent to inquire just what these offsetting assets are, since the purpose of the depreciation reserve is destroyed if quick assets are not available to care for needed replacements.

In order to provide for the continued existence of actual assets with which to meet depreciation, or to provide means for such replacements as are necessary, it is often considered the part of prudent management to create a depreciation fund or asset account to offset the depreciation reserve or liability account. Where definite assets are thus set aside the utility is enabled at all times to finance replacements, and if the money is invested, the accruing interest is easily accounted for and becomes an addition to the fund. The expenditures for replacements are then recorded by crediting the depreciation fund and charging the depreciation reserve account, thus simultaneously diminishing the liability and reducing the depreciation fund.

This method is one generally obtaining in European franchises providing for ultimate purchase by the government and the maintenance of the property until the purchase agreement is consummated. Such depreciation funds are also in some cases, as stated above, provided for the purpose of covering depreciation under the sinking fund method. It is obvious, however, that they can only be so created in cases where divisible profits are available for such purposes. Depreciation reserve accounts, on the other hand, are not dependent upon immediately available profits of this kind and can therefore be created at any time.

In conclusion, I again wish to call your attention to the importance of depreciation, and to emphasize its far-reaching effect upon the rates, earnings, values, and other features of public utilities. I also wish to point to the need for a better general understanding of the nature and meaning of depreciation in all its aspects on the part of those who are interested therein. While depreciation is now earnestly studied by some, it is much neglected by others. It is as yet less well understood by the many than any other equally important problem that enters into the operation, management, and regulation of public utilities. Failure to fully comprehend that depreciation is not only an operating expense, but one of the most important items therein, has often led to unjust complaints of excessive rates, to overstatements of the profits in the business, and to unduly run down conditions of the plants and the service. In some instances at least, it has even been more or less responsible for orders by courts and commissions, the justice of which has been seriously questioned. Errors of this kind are not only out of line with public policy, but in the long run they result in serious inconveniences and losses, both to the utilities and to the public.

While such mistakes would seem to be preventable, they can apparently not be stopped except through more general dissemination of information and facts which tend to disclose the real nature and the full meaning of depreciation. Such information and such facts should be obtained from the plants themselves. They are more readily available to the management of such plants than to anyone else, and it is to them, also, that they are likely to be of the greatest importance. It would therefore seem that the managements might properly render material assistance in furnishing and distributing such information and facts as will tend to throw light on the more obscure and disputed points of this important subject. Organizations, such as the one before which I now have the honor of appearing, through investigations and reports by standing committees, or in other ways, can also accomplish a great deal in this respect. It is a subject that should also be fully examined and reported upon by public service commissions.

At present there appears to be special need for information which will shed further light on the life of the various classes of property in public utility plants, and the methods under which this life can best be determined, as well as upon the best and most economical methods of financing or providing for such depreciation. These questions should be studied and investigated for individual plants operating under various conditions. The facts obtained in connection therewith should also be carefully collated, analyzed and reported upon. Investigations of this kind could hardly fail to be of the greatest value to both the utilities and the public.

TABLES

Computations for determining the life of a plant under the "dollar-year" method and under the "straight line" method are illustrated in tables 1 to 4 inclusive. Table 1 shows the composite life of a typical water works plant as obtained under the "dollar-year" method. Table 2 shows the life of the same plant as obtained under the second method described, the one mostly used by the Wisconsin commission. Tables 3 and 4 illustrate the same facts for an electric lighting plant. In examining these tables it will be noticed that the results are the same under both methods. The average life is found to be 61.64 years for water works and 17.15 years for the electric plant.

Water Works.

TABLE 1.

"DOLLAR-YEAR" METHOD.

Class.	Life.	Cost of reproduction new.	Scrap value.	Cost new less scrap.	Times renewed in 100 year period.	Dollars required in 100 year period.	Dollar-years.
		100245		100245		2004900	1302433
A	5	$245	0	$245	20.00	$4,900	24,500
B	15	2,020	0	2,020	6.67	13,473	202,095
C	20	5,950	469	5,481	5.00	27,405	548,100
D	25	3,177	922	2,255	4.00	9,020	225,500
E	30	23,193	327	22,866	3.33	76,143	2,284,290
F	40	19,080	40	19,040	2.50	47,600	1,904,000
G	50	59,964	3,016	56,918	2.00	113,896	5 694,800
H	100	208,070	22,121	185,949	1.00	185,949	18,594,900
		$321,699	$26,895	$294,804	....	$478,386	29,478,185

Average life $\frac{29,478,185}{478,386}$ = 61.64 years. 1.62%

TABLE 2.

STRAIGHT LINE METHOD.

Class.	Life.	Cost of reproduction new.	Scrap value.	Cost new less scrap.	Annual per cent of depreciation.	Annual amount required to cover depreciation.
A	5	$245	0	$245	20 00	$49
B	15	2,020	0	2,020	6.67	135
C	20	5,950	469	5,481	5.00	274
D	25	3,177	922	2,255	4.00	90
E	30	23,193	327	22,866	3.33	761
F	40	19,080	40	19,040	2.50	476
G	50	59,964	3,016	56,948	2.00	1,139
H	100	208,070	22,121	185,949	1.00	1,859
		$321,699	$26,895	$294,804	....	$4,783

Average life $\frac{294,804}{4,783}$ = 61.64 years.

Electric Lighting and Power Plant.

TABLE 3.

"DOLLAR-YEAR" METHOD.

Class.	Life.	Cost of reproduction new.	Scrap value.	Cost new less scrap.	Times renewed in 75 year period.	Dollars required in 75 year period.	Dollar years.
A	5	$210	$0	$210	15.00	$3,150	15,750
B	8	7,124	14	7,110	9.38	66,692	533,536
C	10	17,361	153	17,208	7.50	129,060	1,290,600
D	12	26,272	0	26,272	6.25	164,200	1,970,400
E	15	143,470	11,920	131,550	5.00	657,750	9,866,250
F	16	65,632	33,375	32,258	4.69	151,290	2,420,640
G	20	113,336	9,239	104,097	3.75	390,364	7,807,280
H	25	43,747	7,631	36,116	3.00	108,348	2.708,700
I	50	14,337	0	14,337	1.50	21,506	1,075,300
J	60	1,165	0	1,165	1.25	1,456	87,360
K	75	21,920	0	21,920	1.00	21,920	1,644,000
		$1545,74	$62,331	$392,243	....	$1,715,736	29,419,816
		12% overhead.	....	47,069			
				$439,312			

$$\text{Average life } \frac{29,419,861}{1,715,736} = 17.15 \text{ years.}$$

TABLE 4.

STRAIGHT LINE METHOD.

Class.	Life.	Cost of reproduction new.	Scrap value.	Cost new less scrap.	Annual per cent of depreciation.	Annual amount required to cover depreciation.
A	5	$210	$0	$210	20.00	$42
B	8	7,124	14	7,110	12.50	889
C	10	17,361	153	17,208	10.00	1,721
D	12	26,272	0	26,272	8.33	2,188
E	15	143,470	11,920	131,550	6:67	8,774
F	16	65,632	33,374	32,258	6.25	2,016
G	20	113,336	9,239	104,097	5.00	5,205
H	25	43,747	7,631	36,116	4.00	1.445
I	50	14.337	0	14,337	2.00	287
J	60	1,165	0	1,165	1.67	19
K	75	21,920	0	21,920	1.33	292
		$454,574	$62,331	$392,243	....	$22,878
		12% overhead	....	47,069	....	2,745
				$439,312	... .	$25,623

$$\text{Average life } \frac{392,243}{22,878} = 17.15 \text{ years.}$$

Formula: S = total cost new less scrap; V = total annual fund; N = life. $N = \frac{S}{V}$

TABLE 5.

SINKING FUND METHOD (2 per cent).

Class.	Life.	Cost of reproduction new.	Scrap value.	Cost new less scrap.	Annual per cent reserved on 2 per cent basis.	Annual fund.
A	5	$210	$0	$210	19.21	$40
B	8	7,124	14	7,110	11.65	828
C	10	17,361	153	17,208	9.13	1,571
D	12	26,272	0	26,272	7.46	1,960
E	15	143,470	11,920	131,550	5.78	7,604
F	16	65,632	33,374	32,258	5.36	1,729
G	20	113,336	9,239	104,097	4.12	4,289
H	25	43.747	7,631	36,116	3.12	1,127
I	50	14,337	0	14,337	1,18	169
J	60	1,165	0	1,165	.88	10
K	75	21,920	0	21,920	.58	127
		$454,574	$62,331	$392,243	....	$19,454
		12% overhead	....	47,069	....	2,334
				$439,312	....	$21,788

Average life $\frac{19,454}{392,243}=.04959=17.16$ years.

Formula: $.04959=\frac{.02}{(1.02)^n-1.}$

TABLE 6.

SINKING FUND METHOD. (4 per cent)

Class.	Life.	Cost of reproduction new.	Scrap value.	Cost new less scrap.	Annual per cent reserved on 4 per cent basis.	Annual fund.
A	5	$210	$0	$210	18.46	$39
B	8	7,124	14	7,110	10.85	771
C	10	17,361	153	17,208	8.33	1,433
D	12	26,272	0	26,272	6.65	1,747
E	15	143,470	11,920	131,550	4.99	6,564
F	16	65,632	33.374	32.258	4.58	1,478
G	20	113,336	9.239	104,097	3.36	3,498
H	25	43,747	7,631	36,116	2.40	867
I	50	14,337	0	14,337	.65	93
J	60	1,165	0	1,165	.42	5
K	75	21,920	0	21,920	.22	48
		$454,574	$62,331	$392,243	....	$16,543
		12% overhead.	....	47,069	....	1,985
				$439,312	....	$18,528

Average life $\frac{16,543}{392,243} = .04217 = 17.01$ years.

Formula:— $.04217 = \frac{.04}{(1.04)^n - 1}$

TABLE 7.

DIMINISHING VALUE METHOD.

Year.	Value at beginning of year.	Depreciation at 10.92 per cent of diminishing value.
1	$454,574	$49,639
2	404,935	44,219
3	360,716	39,390
4	321,326	35,089
5	286,237	31,257
6	254,980	27,844
7	227,136	24,803
8	202,333	22.095
9	180,238	19,682
10	160,556	17,533
11	143,023	15,618
12	127,405	13,913
13	113.492	12,393
14	101,099	11,040
15	90,059	9,834
16	80,225	8,761
17	71,464	7,804
18	63,660	1,043
18.15 residual value	[1]62,617	
		$391,957

Formula: $r = 1 - \sqrt[n]{\frac{v_2}{v_1}}$; r = rate: n = life; v_1 = cost new;

v_2 = scrap value.

$$r = 1 - \sqrt[17.15]{\frac{62,331}{454,574}}$$

Log. 62,331 = 4.79470
" 454,574 = 5.65760
9.13710 − 10

$$\frac{9.13710 - 10}{17.15} = 9.94978 - 10 = .8908$$

$$r = 1 - .8908 = .1092 \text{ or } 10.92\%$$

---

[1] Owing to the elimination of fractions the balance does not exactly correspond with the assumed residual value.

TABLE 8.

ANNUITY METHOD.

Year.	Cost price or balance at beginning of each year.	Interest (6 per cent.)	Cost price plus interest.	Gross depreciation charge.	Balance.	Gross depreciation charge less interest.
1	$454,574	$27,274	$481,848	$41,005	$440,843	$13,731
3	440,843	26,451	467,294	41,005	426,289	14,554
3	426,289	25,577	451,866	41,005	410,861	15,428
4	410,861	24,652	435,513	41,005	394,508	16,353
5	394,508	23,670	418,178	41,005	377,173	17,335
6	377,173	22,630	399,803	41,005	358,798	18,375
7	358,798	21,528	380,326	41,005	339,321	19,477
8	339,321	20,359	359,680	41,005	318,675	20,646
9	318,675	19,121	337,796	41,005	296,791	21,884
10	296,791	17,807	314,598	41,005	273,593	23,198
11	273,593	16,416	290,009	41,005	249,004	24,589
12	249,004	14,940	263,944	41,005	222,939	26,065
13	222,939	13,376	236,315	41,005	195,310	27,629
14	195,310	11,719	207,029	41,005	166,024	29,286
15	166,024	9,961	175,985	41,005	134,980	31,044
16	134,980	8,099	143,079	41,005	102,074	32,906
17	102,074	6,124	108,198	41,005	67,193	34,881
17.15	67,193	605	67,798	6,151	61,647	5,546
	[1]61,647	....	....	703,236	....	392,927

Formula:

$$D = V_1 . R^n - V_2 \div \frac{R^n - 1}{R - 1}$$

D = depreciation; V_1 = cost new; V_2 = scrap value; R = 1 plus rate of interest; n = average life.

$$D = 454,574\ (1.06)^{17.15} - 62,331 \div \frac{(1.06)^{17.15} - 1}{(1.06) - 1}$$

$$= 1,235,078 - 62,331 \div \frac{1.717}{.06}$$

$$= 1,172,747 \div 28.6$$

$$= 41,005$$

---

[1] Owing to elimination of fractions the balance does not exactly correspond with assumed residual value.

TABLE 9.

COMPARISON OF ANNUAL RESERVES SET ASIDE TO COVER DEPRECIATION UNDER STRAIGHT LINE, SINKING FUND, DIMINISHING VALUE, AND ANNUITY METHODS.

Year.	(Table 4.)	(Table 5.)	(Table 6.)	(Table 7.)	(Table 8.)
	Straight line.	2 per cent sinking fund.	4 per cent sinking fund.	Diminishing value.	Annuity (gross charge less interest.)
1..........	$22,878	19,454	$16,543	$49,639	$13,731
2..........	22,878	19,843	17,205	44,219	14,554
3..........	22,878	20,240	17,893	39,390	15,428
4..........	22,878	20,645	18,609	35,089	16,353
5..........	22,878	21,057	19,352	31,257	17,335
6..........	22,878	21,479	20,126	27,844	18,375
7	22,878	21,909	20,932	24,803	19,477
8..........	22,878	22,347	21,769	22,095	20,646
9..........	22,878	22,794	22,641	19,682	21,884
10..........	22,878	23,249	23,545	17,533	23,198
11..........	22.878	23,712	24,487	15,618	24,589
12..........	22,878	24,189	25,468	13,913	26,065
13..........	22,878	24.672	26,485	12,393	27,629
14..........	22,878	25,166	27,546	11,040	29,286
15..........	22,878	25,670	28,647	9,834	31,044
16..........	22,878	26,183	29,793	8,761	32,906
17..........	22,878	26,707	30,985	7,804	34,881
17.15.......	3,431	[1]3,112	[2]165	1,043	5,546
Total....	$392,357	$392,428	$392,190	$391,957	$392,927

[1] .16 year.
[2] .01 year.

TABLE 10.

RELATION OF DEPRECIATION CHARGES TO DEPRECIATION RESERVE

STRAIGHT LINE BASIS—HYPOTHETICAL ELECTRIC PLANT.

Italic figures denote deficits.

Period from	Charge.	Credit.	Credit balance.	Cumulative balance.
1st to 5th year inclusive......	$210	$114,390	$114,180	$114,180
6th to 8th " "	7,110	68,634	61,524	175,704
9th to 10th " "	17,418	45,756	28,338	204,042
11th to 12th " "	26,272	45,756	19,484	223,526
13th to 15th " "	131,760	68,634	*63,126*	160,400
16th to 16th " "	39,368	22,878	*16.490*	143,910
17th to 20th " "	121,515	91,512	*30,003*	113,907
21st to 24th " "	33,382	91,512	58,130	172,037
25th to 25th " "	36,326	22,878	*13,448*	158,589
26th to 30th " "	148,968	114,390	*34,578*	124,011
31st to 32nd " "	39,368	45,756	6,388	130,399
33rd to 35th " "	210	68,634	68,424	198,823
36th to 36th " "	26,272	22,878	*3,394*	195,429
37th to 40th " "	128,625	91,512	*37,113*	158,316
41st to 45th " "	131,760	114,390	*17,370*	140,946
46th to 48th " "	65,640	68,634	2,994	143,940
49th to 50th " "	57,871	45,756	*12,115*	131,825
51st to 55th " "	210	114,390	114,180	246,005
56th to 56th " "	7.110	22,878	15,768	261,773
57th to 60th " "	280,502	91,512	*188,990*	72,783
61st to 64th " "	39,368	91,512	52,144	124,927
65th to 65th " "	210	22,878	22,668	147,695
66th to 70th " "	17,418	114,390	96.972	244,567
71st to 72nd " "	33,382	45.756	12.374	256,941
73rd to 75th " "	189,796	68,634	*121,162*	135,779
	$1,580,071	$1,715,850	$135,779	....

TABLE 11.

RELATION OF DEPRECIATION CHARGES TO DEPRECIATION RESERVE.

2 PER CENT SINKING FUND BASIS.—HYPOTHETICAL ELECTRIC PLANT.

Italic figures denote deficits.

Period from	Charge.	Credit.	Credit balance.	Cumulative balance.
1st to 5th year inc.	$210	$101,239	$101,029	$101,029
5th to 8th “ “	7,110	65,735	58,625	159,654
9th to 10th “ “	17,418	46,043	28,625	188,279
11th to 12th “ “	26,272	47,901	21,629	209,908
13th to 15th “ “	131,760	75,508	*56,252*	153,656
16th to 16th “ “	39,368	26,183	*13,185*	140,471
17th to 20th “ “	121,515	86,244	*35,271*	105,200
21st to 24th “ “	33,382	85,090	51,708	156,908
25th to 25th “ “	36,326	22,347	*13,979*	142,949
26th to 30th “ “	148,968	118,616	*30,352*	112,577
31st to 32nd “ “	39,368	50,836	11,468	124,045
33rd to 35th “ “	210	72,344	72,134	196,179
36th to 36th “ “	26,272	19,843	*6,429*	189,750
37th to 40th “ “	128,625	83,421	*45,204*	144,546
41st to 45th “ “	131,760	114,011	*17,749*	126,797
46th to 48th “ “	65,640	74,027	8,387	135,184
49th to 50th “ “	57,871	51,853	*6,018*	129,166
51st to 55th “ “	210	106,889	106,679	235,845
56th to 56th “ “	7,110	21,057	13,947	249,792
57th to 60th “ “	280,502	88,529	*191,973*	57,819
61st to 64th “ “	39,368	95,822	56,454	114,273
65th to 65th “ “	210	25,166	24,956	139,229
66th to 70th “ “	17,418	117,857	100,439	239,668
71st to 72nd “ “	33,382	40,885	7,503	247,171
73rd to 75th “ “	189,796	64,445	*125,351*	121,820
	$1,580,071	$1,701,891	$121,820	....

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TABLE 12.

RELATION OF DEPRECIATION CHARGES TO DEPRECIATION RESERVE,

4 PER CENT SINKING FUND BASIS.—HYPOTHETICAL ELECTRIC PLANT.

Italic figures denote deficits.

Period from	Charge.	Credit.	Credit balance.	Cumulative balance.
1st to 5th year inclusive......	$210	$89,602	$89,392	$89,392
6th to 8th " "	7,110	62,827	55,717	145,109
9th to 10th " "	17,418	46,186	28,768	173,877
11th to 12th " "	26,272	49,955	23,683	197,560
13th to 15th " "	131,760	82,678	*49,082*	148,478
16th to 16th " "	39,368	29,792	*9,576*	138,902
17th to 20th " "	121,515	82,626	*38,889*	100,013
21st to 24th " "	33,382	79,019	45,637	145,650
25th to 25th " "	36,326	21,769	*14,557*	131,093
26th to 30th " "	148,968	122,626	*26,342*	104,751
31st to 32nd " "	39,368	56,193	16,825	121,576
33rd to 35th " "	210	77,320	77,110	198,686
36th to 36th " "	26,272	17,205	*9,067*	189,619
37th to 40th " "	128,625	75,980	*52,645*	136,974
41st to 45th " "	131,760	113,374	*18,386*	118,588
46th to 48th " "	65,640	79,499	13,859	132,447
49th to 50th " "	57,871	58,439	568	133,015
51st to 55th " "	210	101,235	101,025	234,040
56th to 56th " "	7,110	19,352	12,242	246,282
57th to 60th " "	280,502	85,468	*195,034*	51,348
61st to 64th " "	39,368	99,985	60,617	111,865
65th to 65th " "	210	27,546	27,336	139,201
66th to 70th " "	17,418	123,172	105,754	244,955
71st to 72nd " "	33,382	36,502	3,120	248,075
73rd to 75th " "	189,796	60,410	*129,386*	118,689
	$1,580,071	$1,698,760	$118,689	....

TABLE 13.

RELATION OF DEPRECIATION CHARGES TO DEPRECIATION RESERVE.

DIMINISHING VALUE BASIS.—HYPOTHETICAL ELECTRIC PLANT.

Italic figures denote deficits.

Period from	Charge.	Credit.	Credit balance.	Cumulative balance.
1st to 5th year inc	$210	$199,594	$199,384	$199,384
6th " 8th " "	7,110	74,742	67,632	267,016
9th " 10th " "	17,418	37,215	19,797	286,813
11th " 12th " "	26,272	29,531	3,259	290,072
13th " 15th " "	131,760	33,267	*98,493*	191,579
16th " 16th " "	39,368	8,761	*30,607*	160,972
17th " 20th " "	121,515	141,052	19,537	180,509
21st " 24th " "	33,382	118,993	85,611	266,120
25th " 25th " "	36,326	22,095	*14,231*	251,889
26th " 30th " "	148,968	79,139	*69,829*	182,060
31st " 32nd " "	39,368	20,874	*18,494*	163,566
33rd " 35th " "	210	66,204	65,994	229,560
36th " 36th " "	26,272	44,219	17,947	247,507
37th " 40th " "	128,625	133,580	4,955	252,462
41st " 45th " "	131,760	99,731	*32,029*	220,433
46th " 48th " "	65,640	37,346	*28,294*	192,139
49th " 50th " "	57,871	18,595	*39,276*	152,863
51st " 55th " "	210	176,141	175,931	328,794
56th " 56th " "	7,110	31,257	24,147	352,941
57th " 60th " "	280,502	94,424	*186,078*	166,863
61st " 64th " "	39,368	59,457	20,089	186,952
65th " 65th " "	210	11,040	10,830	197,782
66th " 70th " "	17,418	120,257	102,839	300,621
71st " 72nd " "	33,382	74,479	41,097	341,718
73rd " 75th " "	189,796	83,904	*105,892*	235,826
	$1,580,071	$1,815,897	$235,826	....

TABLE 14.

RELATION OF DEPRECIATION CHARGES TO DEPRECIATION RESERVE.

ANNUITY METHOD.—HYPOTHETICAL ELECTRIC PLANT.

Italic figures denote deficits.

Period from	Charge.	Credit.	Credit balance.	Cumulative balance.
1st to 5th year inc.	$210	$77,401	$77,191	$77,191
6th to 8th " "	7,110	58,498	51,388	128,579
9th to 10th " "	17,418	45,082	27,664	156,243
11th to 12th " "	26,272	50,654	24,382	180,625
13th to 15th " "	131,760	87,959	*43,801*	136,824
16th to 16th " "	39,368	32,906	*6,462*	130,362
17th to 20th " "	121,515	78,594	*42,921*	87,441
21st to 24th " "	33,382	71,540	38,158	125,599
25th to 25th " "	36,326	20,646	*15,680*	109,919
26th to 30th " "	148,968	123,365	*25,603*	84,316
31st to 32nd " "	39,368	60,330	20,962	105,278
33rd to 35th " "	210	81,518	81,308	186,586
36th to 36th " "	26,272	14.554	*11,718*	174,868
37th to 40th " "	128,625	67,491	*61,134*	113,734
41st to 45th " "	131,760	109,794	*21,966*	91,768
46th to 48th " "	65,640	82,980	17,340	109,108
49th to 50th " "	57,871	63,950	6,079	115,187
51st to 55th " "	210	94,947	94,737	209,924
56th to 56th " "	7,110	17,335	10,225	220,149
57th to 60th " "	280,502	80,382	*200,120*	20,029
61st to 64th " "	39,368	101,481	62,113	82,142
65th to 65th " "	210	29,286	29,076	111,218
66th to 70th " "	17,418	127,116	109,698	220,916
71st to 72nd " "	33,382	31,781	*1,601*	219,315
73rd to 75th " "	189,796	55,187	*134,609*	84,706
	$1,580,071	$1,664,777	$84,706	....

TABLE 15.

COMPARISON OF THE CUMULATIVE BALANCES AS DETERMINED BY STRAIGHT LINE, SINKING FUND, DIMINISHING VALUE, AND ANNUITY METHODS.

HYPOTHETICAL ELECTRIC PLANT.

	Straight line.	2 per cent sinking fund.	4 per cent sinking fund.	Diminishing value.	Annuity method.
At end of 5th year..........	$114,180	$101,029	$89,392	$199,384	$77,191
" " 8th "	175,704	159,654	145,109	267,016	128,579
" " 10th "	204,042	188,279	173,877	286,813	156,243
" " 12th "	223,526	209,908	197,560	290,072	180,625
" " 15th "	160,400	153,656	148,478	191,579	136,824
" " 16th "	143,910	140,471	138,902	160,972	130,362
" " 20th "	113,907	105,200	100,013	180,509	87,441
" " 24th "	172,037	156,908	145,650	266,120	125,599
" " 25th "	158,589	142,929	131,093	251,889	109,919
" " 30th "	124,011	112,577	104,751	182,060	84,316
" " 32nd "	130,399	124,045	121,576	163,566	105,278
" " 35th "	198,823	196,179	198,686	229,560	186,586
" " 36th "	195,429	189,750	189,619	247,507	174,868
" " 40th "	158,316	144,546	136,974	252,462	113,734
" " 45th "	140,946	126,797	118,588	220,433	91,768
" " 48th "	143,940	135,184	132,447	192,139	109,108
" " 50th "	131,825	129,166	133,015	152,863	115,187
" " 55th "	246,005	235,845	234,040	328,794	209,924
" " 56th "	261,773	249,792	246,282	352,941	220,149
" " 60th "	72,783	57,819	51,248	166,863	20,029
" " 64th "	124,927	114,273	111,865	186,952	82,142
" " 65th "	147,695	139,229	139,201	197,782	111,218
" " 70th "	244,567	239,668	244,955	300,621	220,916
" " 72nd "	256,941	247,171	248,075	341,718	219,315
" " 75th "	135,779	121,820	118,689	235,826	84,706
Total..........................	$4,180,454	$3,921,895	$3,800,085	$5,846,441	$3,282,027

Wisconsin Water Utilities.

TABLE 16.

DEPRECIATION RESERVES.

Utility.	Population of city (1910 census).	Cost of reproduction new.	Per cent condition.	Present value.	Composite life (straight line), years.	Composite life (4 per cent sinking fund), years.	Annual fund (straight line).	Per cent of fund total property, including land.
A.	40,384	$690,001	94.6	$653,070	67.29	58.00	$8,548	1.24
B.	25,531	531,020	93.4	496,346	49.86	44.34	8,212	1.55
C.	11,594	401,581	94.0	377.517	63.11	56.25	5,642	1.41
D.	16,773	268,687	84.6	227,445	51.96	47.68	4.458	1,66
E.	14,610	318,327	91.5	291,022	61.62	56.95	4,784	1.50
F.	8,893	185,148	92.3	170.824	67.60	59.60	2,464	1.33
G.	8,692	127.897	88.4	113,060	43.11	55.74	2,325	1.82
H.	5,629	109,432	94.7	100,502	60.55	53.30	....	....
I.	3,793	101,360	93.1	94,319	44.76	44.16	1,145	1.13
J.	7,196	84,276	90.2	77,201	60.03	55.57	1,076	1.28
K.	5,036	73,493	90.1	66,216	56.99	50.65	1,163	1.58
L.	3,830	61,139	92.0	56,285	66.33	58.38	812	1.33
M.	2,675	36,947	92.2	34,072	55.51	51.07	577	1.56
N.	2,907	36.899	90.1	33,225	59.31	51.75	518	1.40
O.	2,582	49,855	92.9	46,315	54.66	48.69	748	1.50
P.	1.808	23,138	89.9	20,804	69.77	62.04	286	1.24
Q.	1,833	11,784	79.6	9,937	35.49	37.00	288	2.44
R.	804	8.115	90.6	7,334	46.40	45.75	162	2.00
S.	15,125	242.327	92.0	224,483	62.90	58.12	2,901	1.20
T.	13.027	220,382	92.9	204,716	66.19	58.51	2,472	1.12
U.	13,894	217.611	93.1	202,579	63.69	56.21	2,784	1.28
V.	18,797	309.449	90.2	279.312	53.49	46.93	8,088	2.61
W.	6.324	120,816	94.7	110,426	55.16	49.33	1,839	1.52
Arith.av	10,076	$183,899	91.0	$169,435	57.55	52.43	$2,786	1.53

Wisconsin Electric Utilities.

TABLE 17.

DEPRECIATION RESERVES.

Utility.	Population of city (1910 census).	Cost of reproduction new.	Per cent condition.	Present value.	Composite life (straight line). years.	Annual fund (straight line).	Per cent of fund to total property including land.
A.	40,384	$342,624	74.1	$253.766	17.91	$16,310	4.76
B.	30,417	478,501	79.4	379,825	17.15	22,876	4.78
C.	18,797	154,023	77.4	119,186	15.55	8,883	5.76
D.	15,125	178,610	83.7	149,581	18.18	9,313	5.21
E.	8,893	75,773	65.3	49,484	15.60	4,650	6.14
F.	5,783	47,230	80.9	38,193	15.49	2.611	5.53
G.	4,717	[1]51,480	74.6	[1]38,436	19.45	2,119	4.12
H.	4,477	[1]56,492	77.2	[1]43,593	13.97	2,896	5.13
I.	3,224	[1]37,583	75.7	[1]28,440	17,31	1,945	5.17
J.	2,692	27,418	63.4	17,389	16.75	1,478	5.39
K.	2,652	35,752	81.5	29,152	16.02	1,928	5.39
L.	2,582	41,511	80 5	33,415	19.29	1,712	4.12
M.	2,450	26,142	62.0	16,223	14.69	1,509	5.77
N.	1,860	25,660	70.8	18,171	15,71	1,191	4.64
O.	1,833	21,180	80.3	17,015	22.38	779	3.68
P.	1.803	[1]19,524	76.8	[1]14,985	20.80	1.210	6.20
Q.	919	11,865	97.4	11.557	15.09	687	5.79
R.	425	17,559	85.0	14,917	18.25	647	3.68
S.	25,531	443,158	78.9	349,846	17.02	24,694	5.57
T.	25,236	119,505	79.9	95,490	16.73	5,846	4.89
U.	11,594	80,079	71.8	57,501	16.03	1,884	2.35
V.[1]	5,036	93,139	70.4	65,567	17.54	3,874	4.16
W.	3,739	35,804	75.1	26,899	18.24	1,861	5.20
Arith. average.. .	9,573	$105,244	76.6	$81,245	17.31	$5,257	4.93

[1] Does not include land.

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